# MERCURY IN THE EFFLUENTS FROM CHLOR-ALKALI PLANTS: SECOND SURVEY AT DRYDEN, OCTOBER, 1975

February, 1976

Ministry of the Environment
Ontario

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Inorganic Trace Contaminants Section
Laboratory Services Branch

February, 1976

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## Note Concerning Company Names:

Since the survey in October, 1975, the Company has announced a change of name effective December 27, 1975 to Reed Ltd., Pulp and Paper Group, Chemical Division, Chloralkali and Silvichemical Products, Dryden, Ontario. For ease of reference, the Company is referred to throughout this report as Dryden Chemicals. Similarly, the kraft pulp and paper mill which is situated in close proximity to the chlor-alkali plant and serves as the prime consumer of Dryden Chemicals products, was formerly known as Dryden Paper Company, Limited. Effective December 27, 1975, the Company name was changed to Reed Ltd., Pulp and Paper Group, Dryden Mill Division. During the survey, the name Reed Paper, Limited was in common use and has been used throughout this report to refer to the kraft pulp and paper mill.

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INTRODUCTION

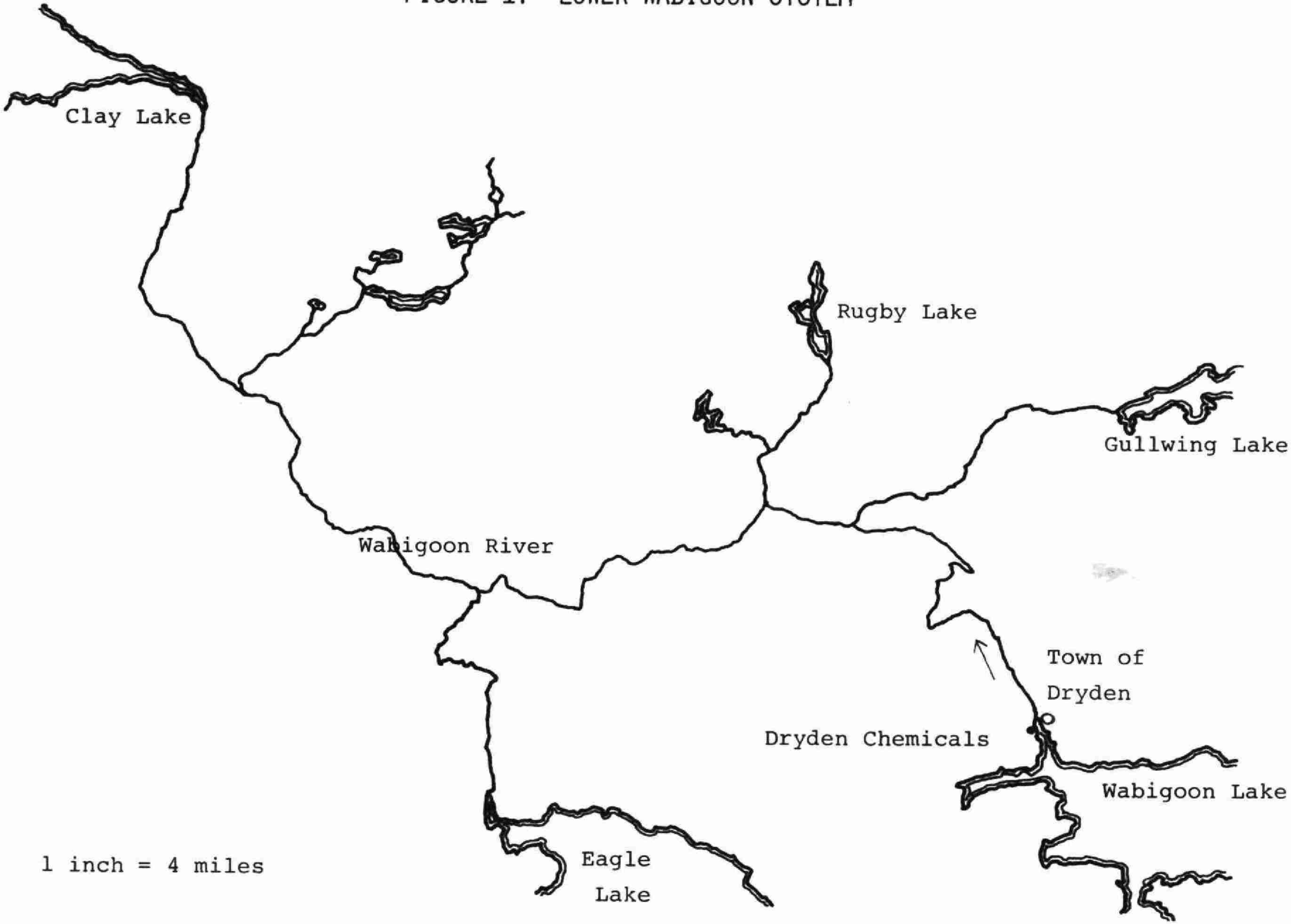
Dryden Chemicals, Limited, operated a mercury cathode chlor-alkali plant in Dryden, Ontario between March, 1962, and October, 1975. In October, 1975, the process was changed to a permionic membrane operation, which does not require the use of mercury. In order to make use of the last opportunity to corroborate and expand the findings of a previous survey in July, 1975, another intensive survey was undertaken from October 9 to 14, 1975.

The chlor-alkali plant is situated in close proximity to Reed Paper Limited (Dryden Division),a kraft pulp and paper mill that is the prime consumer of the products of Dryden Chemicals. The water used in the chlor-alkali plant is taken from the Wabigoon River, approximately one mile downstream from Lake Wabigoon, and the waste water is carried by sewers through the paper mill. The mixed chlor-alkali/kraft mill wastes then flow into the Wabigoon River via a small impoundment area (see Figures 1, 2, and 3).

From 1962 to 1970, Dryden Chemicals released wastes not treated for mercury removal, and this resulted in mercury contamination of sediment and fish downstream from the plant. In March, 1970, a control order from the Ontario Water Resources Commission was issued directing Dryden Chemicals to conduct in-plant modifications for waste water recycling, and separation and treatment of mercury contaminated wastes.

The facilities for the treatment of wastes containing mercury consisted of two settling tanks (capacity 60,000 and 90,000 gallons) into which mercury contaminated water was diverted. After agitation and pH adjustment to neutrality, mercuric sulfide was formed by the addition of sodium sulfide. The mercuric sulfide was then co-precipitated with iron (added as ferric chloride) sulfide, and settling was allowed over 3-4 days. The tank was emptied without filtration through pipes (at the 5 foot level in the 60,000 gallon tank and at the 6 foot level in the 90,000 gallon tank) into the treatment tank drain. This treated effluent was combined

FIGURE 1: LOWER WABIGOON SYSTEM



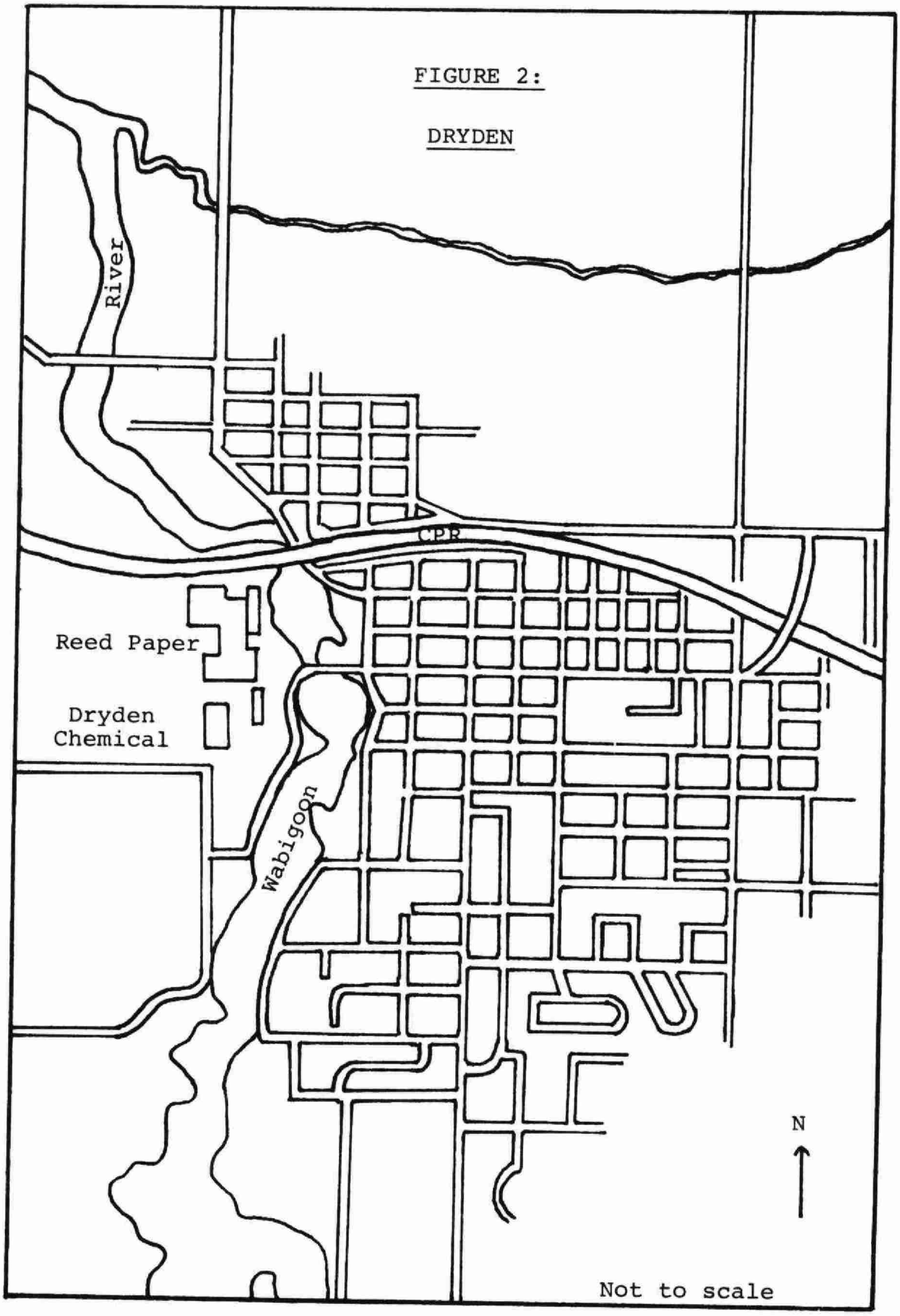
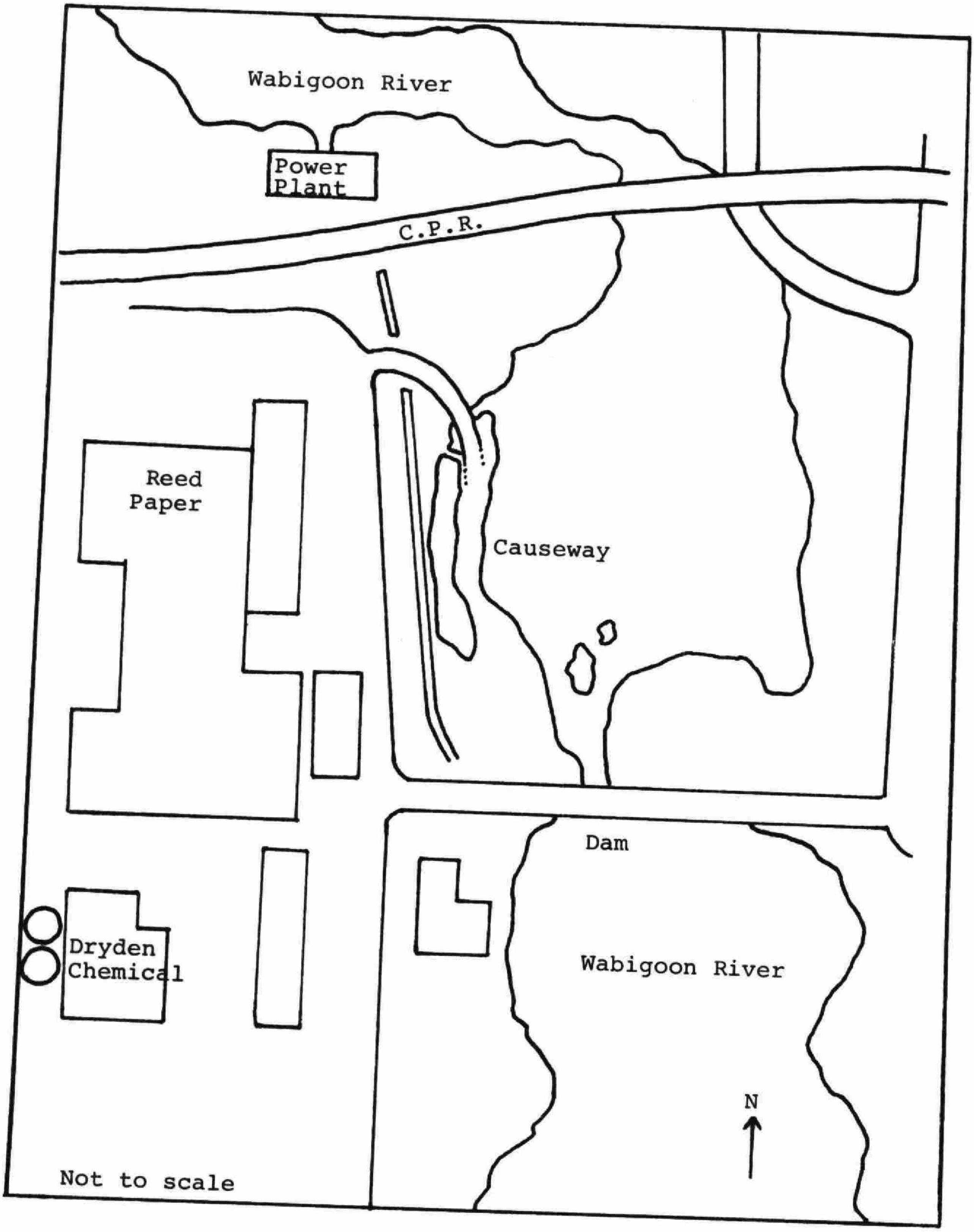


FIGURE 2:
DRYDEN
River
CPR
Reed Paper
Dryden
Chemical
Wabigoon
N
Not to scale

FIGURE 3: REED PAPER / DRYDEN CHEMICAL COMPLEX



with cell cooling water and other effluents from the east header, and flowed through sewer D1 (see Fig. 4) and after combining with some effluents from the kraft mill, emerged in the causeway at sewer B1.

The accumulated precipitate at the bottom of the treatment tank was removed when necessary (about once a year), mixed with concrete, and poured into a polyethylene lined pit located in a zone of impervious clay. The pit is under-drained by a weeping tile running the length of the pit, and two test wells have been drilled so that ground water analyses can be done to assess possible mercury leaching from the pit.

Arising from the stipulations contained in the 1970 control order, Dryden Chemicals Limited is required to maintain records of all mercury discharges in liquid effluent streams emanating from the plant. The mercury discharges are also independently monitored by the Ontario Ministry of the Environment.

A preliminary survey of mercury concentrations in the effluent from the chlor-alkali/kraft mill complex was carried out in July, 1975, and resulted in the following conclusions:

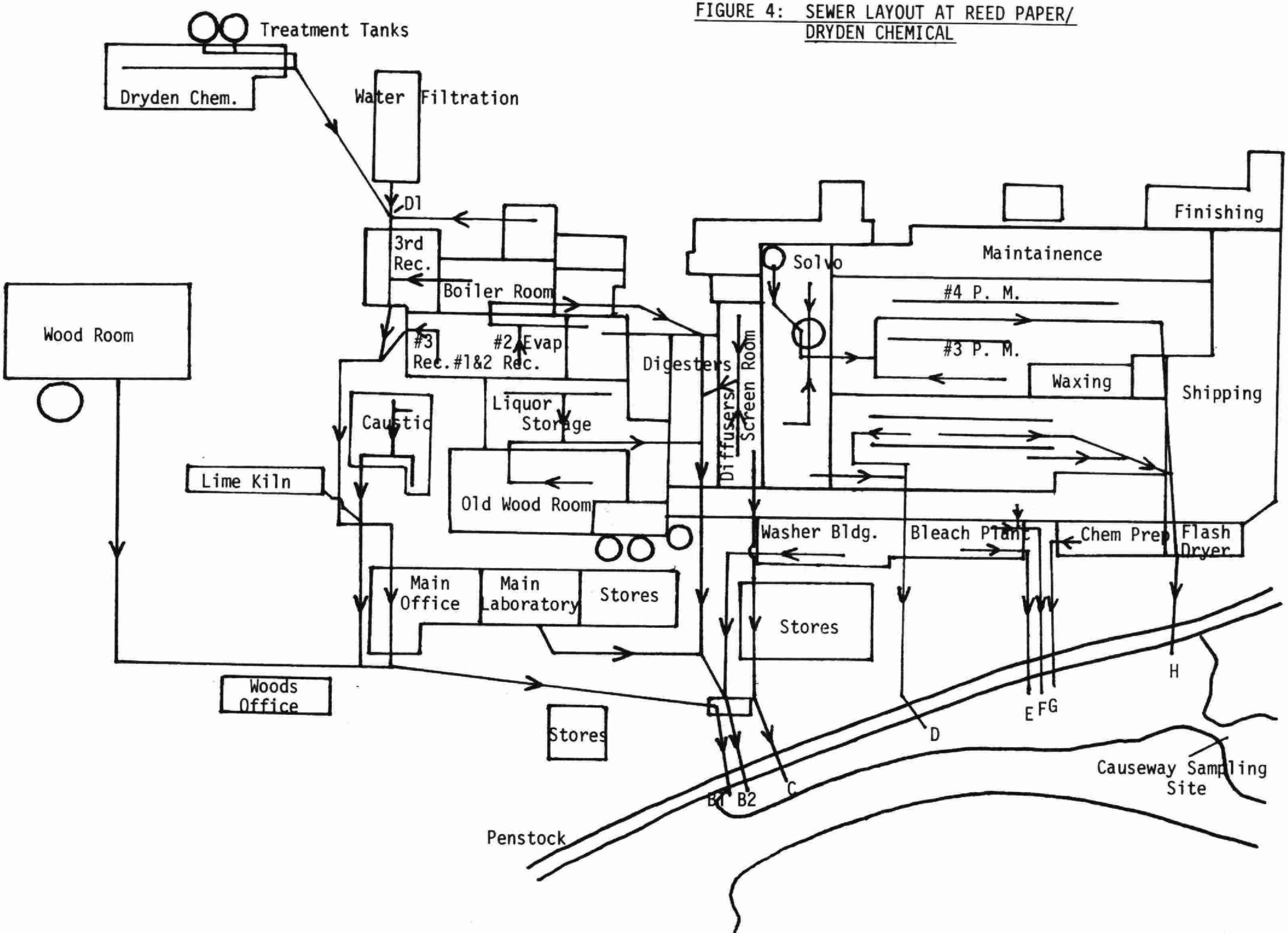
- the mercury losses reported by Dryden Chemical due to discharges of treated effluent accounted for only a portion of the total amount of mercury released to the river system.

- the mercury concentration in the effluent fluctuated considerably, making single grab samples inadequate for determining mercury loadings.

- at least part of the mercury in the effluent was in the particulate form.

- the preservation technique for mercury samples was effective for at least nine days.

FIGURE 4: SEWER LAYOUT AT REED PAPER/ DRYDEN CHEMICAL



The survey in October, 1975, was designed to obtain a more comprehensive picture of mercury discharges in the Dryden plant. Included in the survey were two 24 hour periods in which samples were taken every 30 minutes, and samples taken every 15 minutes during the actual discharges at some of the sampling points. Also, several samples were taken of which portions were filtered, so that the amount of mercury associated with particles could be determined. Several samples were also taken without preservation, to assess how this affects the mercury concentration relative to a preserved portion. The results of this study would aid in evaluating data from composite samples, which often sit without preservatives for several hours.

Mercury analysis on many of the products of Reed Paper and Dryden Chemicals was also performed, and samples of sediment were also analyzed.

## DESCRIPTION OF PROCESSES

### I. CHLORINE AND CAUSTIC (see Fig. 5)

The chlorine and sodium hydroxide were produced in a Krebs electrolytic cell using a mobile mercury cathode. Rock salt ($NaCl$) was dissolved in water to form a brine, which was mixed with barium carbonate and sodium carbonate to precipitate iron, calcium, magnesium and sulfate impurities. After filtration, the pH of the brine was adjusted with hydrochloric acid and fed into the electrolytic cells. Each of the twenty cells consisted of fixed graphite anodes, and 3000 pounds of mercury cathode that flowed down the length of the cell. Gaseous chlorine formed at the anode, and a sodium-mercury amalgam formed at the cathode. Sodium hydroxide and hydrogen were formed by reacting the amalgam with water in a decomposer.

The caustic was filtered before storage, the mercury was returned to the electrolytic cells, and the hydrogen was scrubbed, and either vented to the atmosphere, or used in the production of hydrochloric acid.

After passing through the cell, the depleted brine was treated with hydrochloric acid to drive off the chlorine. The brine was then mixed with rock salt to increase its salt concentration, and returned to the process. The gaseous chlorine was cooled, scrubbed, dried, and liquified.

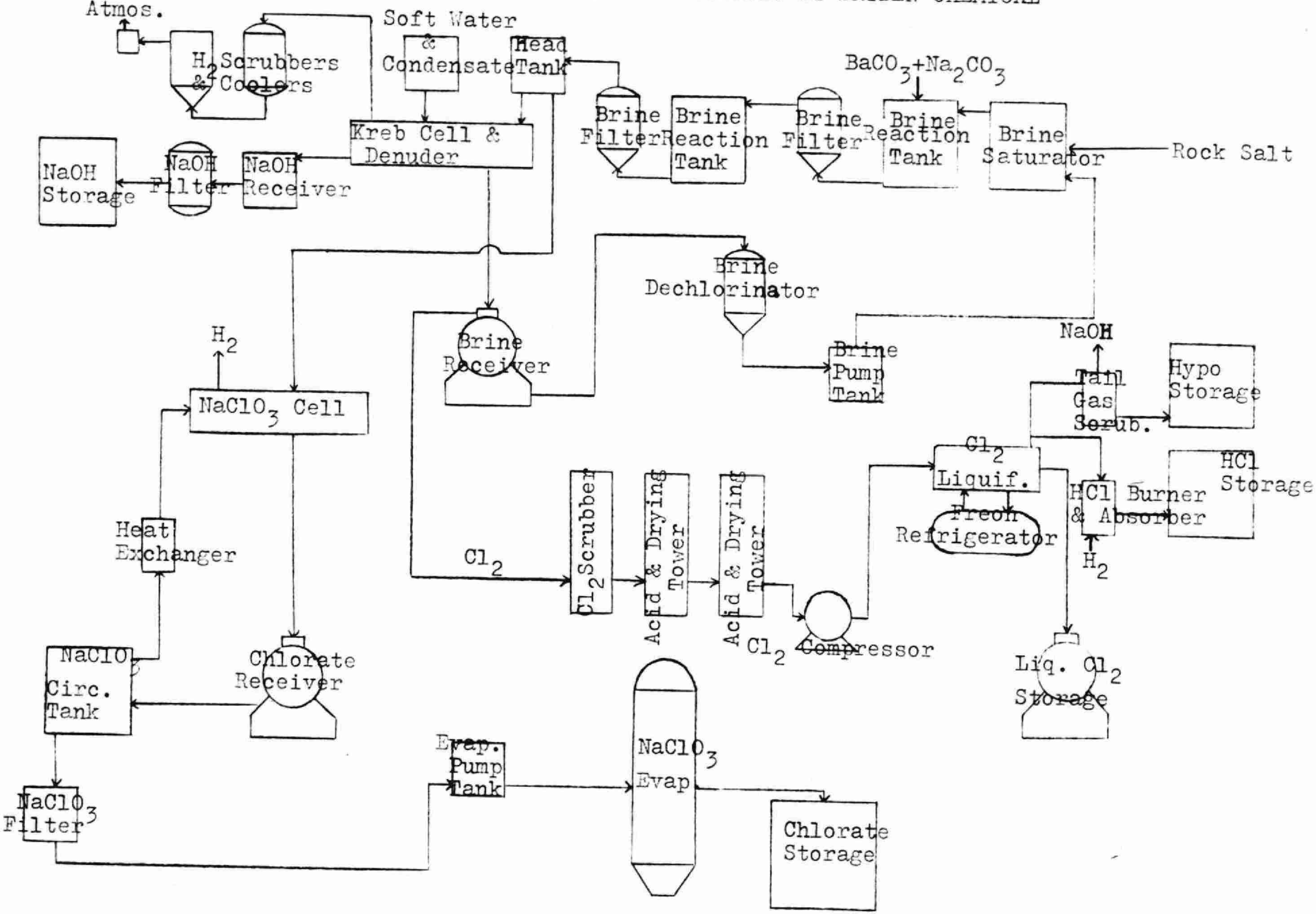
### II. SODIUM HYPOCHLORITE

Sodium hypochlorite ($NaOCl$) was formed by scrubbing chlorine in a tower packed with sodium hydroxide.

### III. HYDROCHLORIC ACID

Gaseous hydrochloric acid was formed by burning chlorine in excess hydrogen. The gas was dissolved in water spray to form liquid hydrochloric acid.

FIGURE 5: SCHEMATIC DIAGRAM OF PROCESSES AT DRYDEN CHEMICAL



## IV. SODIUM CHLORATE

Sodium chlorate was formed by the continuous circulation of brine through an electrolytic cell, in which chloride was oxidized to chlorate and hydrogen was produced. The solution was treated with hydrochloric acid to remove hypochlorite, filtered, and concentrated by passing it through an evaporator.

## CONTROL ON MERCURY DISCHARGES

From March, 1962 to April, 1970, Dryden Chemicals released wastes containing mercury without treatment. Early in 1970, the process waters were separated into mercury contaminated and mercury uncontaminated sewers. In April, 1970, temporary facilities for the removal of mercury from contaminated waste water were installed, and a final design was implemented early in 1971.

The two main features of the mercury removal system were:

a) two treatment tanks (capacity 60,000 and 90,000 gallons) for treating mercury-containing liquid wastes, and
b) disposal of mercury-containing sludges by treatment with concrete and burial of the sludge-concrete mixture in a solid waste disposal site approved by the Ministry of the Environment.

The liquid effluents treated for mercury include spent brine from the chlorate process, gland and seal water from various pumps, leaks, overflows, and floor washings. Sludges from the brine saturators, the brine settling tanks, the chlorate circuit, washings from the brine and caustic filters, and the sludge from the effluent treatment tanks are all mixed with sand and concrete and sent to the landfill site.

## SAMPLING

### I. LIQUID EFFLUENTS

Samples were collected in 8 oz. bacteriological bottles, and preserved with nitric acid and potassium permanganate. The sample locations are shown on Figs. 3 and 4 and described below.

a) Causeway:

This is an open ditch about 150 meters long into which all of the discharges from Dryden Chemicals and Reed Paper emerge. This total effluent was sampled immediately below a flume just before the effluent joined the Wabigoon River via two pipes. The flow through the causeway was approximately 31 million gallons/day.

b) Sewer B1:

This sewer contains all the effluents from Dryden Chemicals as well as wastes from the lime kiln, woodroom, #3 recovery boiler room, #3 evaporator, causticizers, and water filtration.

c) Sewer B2:

Prior to September, 1975, this was the sewer through which the effluent from Dryden Chemicals was discharged. It now contains wastes from the boiler room, #1 and 2 recovery, turpentine recovery, digesters, liquor storage, the main laboratory, and the washer building.

d) Sewer C:

The liquid flow through sewer C is quite minimal, since this sewer serves mainly to carry steam. It includes wastes from the digester blow down, and the condensate and foam tank overflow sewer.

e) Sewer D:

This sewer contains fibres and white water losses from the #1 and 2 paper machines.

f) Sewer E:

Fibre and white water wastes from the bleach plant enter

the causeway through sewer E.

g) Sewer F:

This sewer contains the acid and caustic wastes from the bleach plant.

h) Sewer G:

Waste water and cooling water from the chemical preparation plant are discharged through this sewer.

i) Sewer H:

Sewer H contains wastes (including fibres, white water losses,dyes, starch, and coatings) from the #2, 3, and 4 paper machines, as well as wastes from the screen room, solvo pulper, and the screen dryer.

j) Sewer D1:

This name was assigned to the point of confluence of the effluent from Dryden Chemicals and waste water from the water filtration plant. Samples were taken through a manhole.

k) Treatment Tank Drain:

This is the pipe through which the contents of the settling tanks at Dryden Chemical are emptied. The sampling point was a small tap on the pipe inside the chlor-alkali plant. A small flow was maintained through the tap during a discharge and was collected in a bucket, which was sampled by the company to provide an estimate of the average concentration of mercury in the treated effluent.

l) East and West Headers:

These are two pipes from Dryden Chemical containing untreated effluent. The east header contains cooling water from the brine coolers, the water-jacketed hydrogen scrubber, the freon chiller, Gabbioneta compressors, and ejector water from the chlorate crystallizer. The west header includes cooling water from the chlorine scrubber tower, the acid tower, and the chlorate heat exchangers. The water in the east and west headers enters the causeway through sewer B1.

m) Power Plant:

The power plant is situated about 0.5 km downstream of Reed Paper, and supplies power to the mill from water diverted to it from the Wabigoon River above the mill. ( see Fig. 3).

n) Wabigoon River:

Samples were taken above the dam that diverts most of the Wabigoon River into the mill. There were also samples taken from the government dock at Lake Wabigoon.

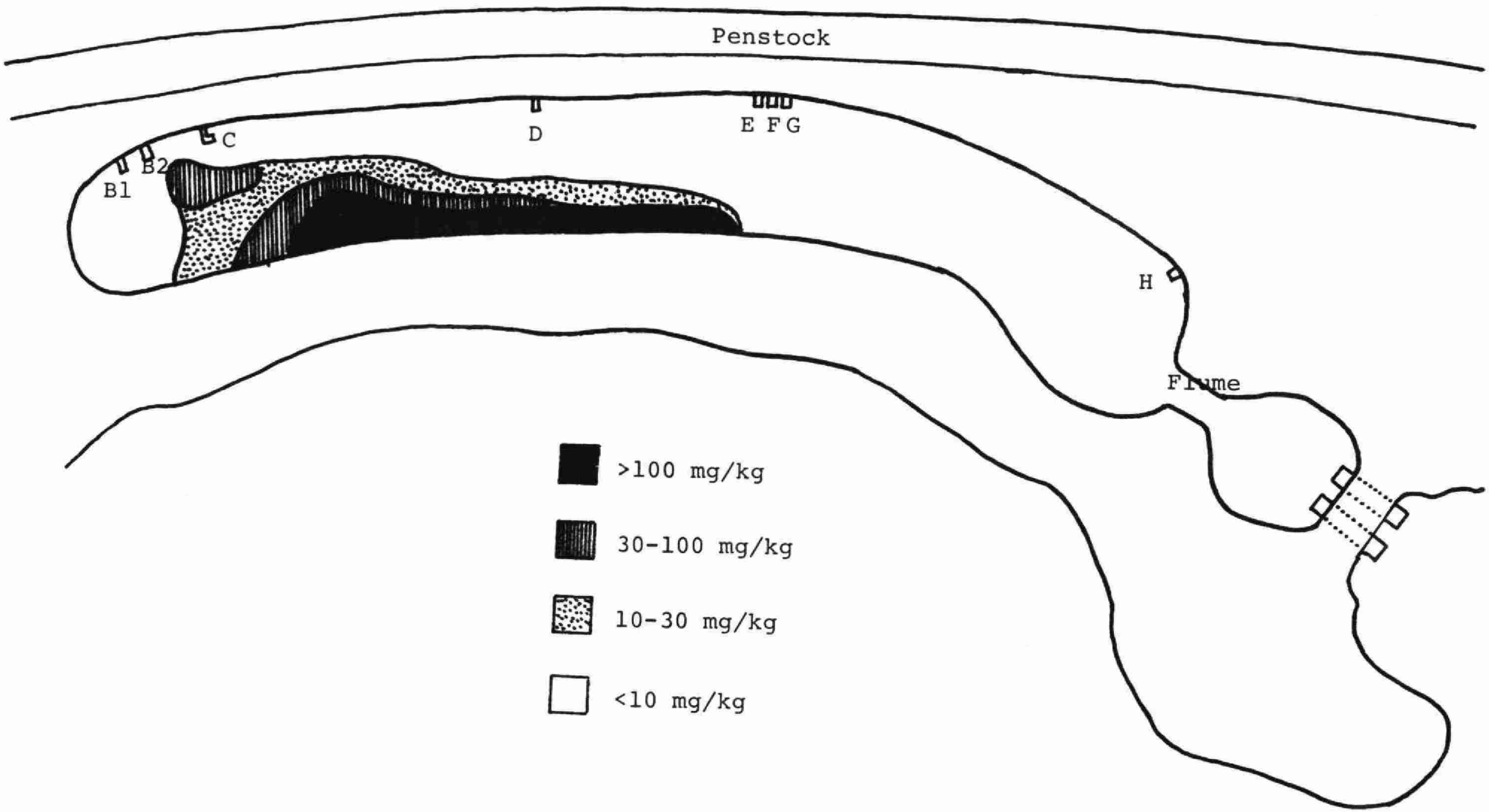
## II. PRODUCTS

Samples of hypochlorite, chlorate, hydrochloric acid, and filtered caustic were obtained from Dryden Chemicals and analyzed for mercury. In addition samples of unbleached, semi-bleached, and bleached pulp, and a variety of paper samples from Reed Paper were analyzed.

## III. SEDIMENTS

Several core and scoop samples were also taken in the causeway (see Fig. 6). In some of the locations, the consistency of the bottom enabled core samples to be taken, while the rest of the samples were scoops, or 10 cm cores, with no partitioning possible.

FIGURE 6: MERCURY CONCENTRATION IN CAUSEWAY SEDIMENT



ANALYSIS

The method of analysis has been described in detail elsewhere (J. N. Bishop, L. A. Taylor, and B. P. Neary, The Determination of Mercury in Environmental Samples, M.O.E. Report, January, 1973).

Water samples are digested with nitric acid, sulfuric acid, potassium permanganate and potassium persulfate for two hours at 80$^{o}$C to ensure breakdown of organic materials, and to convert all the mercury present to the divalent ion. After cooling, the excess potassium permanganate is reduced with hydroxylamine sulfate, then the mercury is reduced to its elemental state with stannous sulfate. The sample is then aerated, and the resulting stream of air and volatilized mercury is passed through an ultraviolet absorption tube, and the absorption at 253.7 nm is recorded. The absorption is proportional to the mercury concentration of the sample. The limit of detection by this method is approximately 0.05 ug/l (ppb).

The sediment samples are heated for two minutes in 10 ml of aqua regia, cooled, then digested for 30 minutes with potassium permanganate added. After cooling, and reducing the permanganate with hydroxylamine sulfate, the samples are filtered, then reduced and aerated like the water samples. The limit of detection is usually 0.02 mg/kg (ppm).

Paper products were analyzed using the "hot block" digestion. Samples were digested at 210$^{o}$C in nitric-sulfuric acids, further digested with $KMnO_4$, and were then reduced, aerated and analyzed much like water samples.

## RESULTS

### I. EFFLUENTS

Wastewater that was treated for the removal of mercury was released every 4-6 days under normal operating conditions. The results of the analyses of effluents have been broken down to reflect this periodicity. All raw data are attached in Appendix I.

October 9-10:
A total of 25,850 Imperial gallons of treated effluent was released starting at 0830. Since this was coincident with the arrival of the sampling team in Dryden, the company was requested to stop the discharge at 0900 to allow the positioning of the samplers. The discharge was restarted at 1055 and continued until 1305.

The mercury concentrations in sewer B1 and the causeway from the period 1000 October 9 to 1230 October 10 are shown in Figs. 7 and 8. During this time, the mercury concentration in the causeway ranged from 0.23 to 1.30 ug/l, and the concentration in sewer B1 ranged from 0.49 to 15.6 ug/l. For the period 1000 to 1330, October 9, the average concentration in the causeway was 0.64 ug/l, and over the next 24 hours the average concentration was 0.51 ug/l. The average mercury levels in sewer B1 during the same periods were 3.86 ug/l, and 1.60 ug/l, respectively.

Sewer D1, which is between the treatment tank outlet and sewer B1, had a mercury concentration ranging between 2.0 and 7.0 ug/l. The contents of the treatment tank ranged between 23 and 1800 ug/l mercury, and averaged 305 ug/l.

October 11-13:
During these days, at least two samples per day were taken from the causeway, from each of the sewers, and from the east and west headers. In this time, the concentration of mercury in sewer B1 ranged between 0.98 and 3.6 ug/l, while the level in the causeway ranged from 0.27 to 0.74 ug/l. The mercury concentration in sewers B2, D, E, F, G, and H, all remained below 1 ug/l.

FIGURE 7

MERCURY CONCENTRATION IN CAUSEWAY EFFLUENT, OCTOBER 9-10, 1975

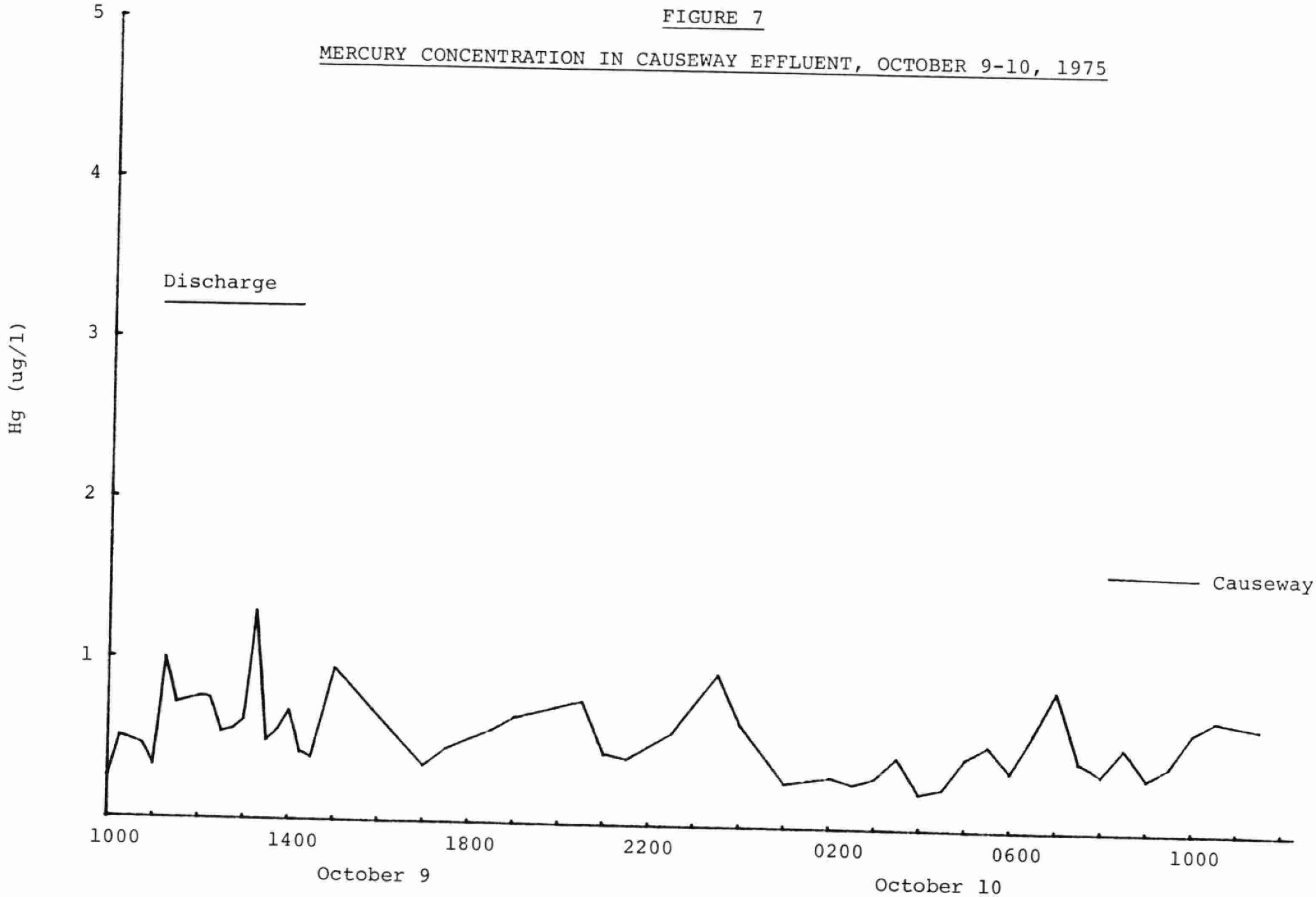
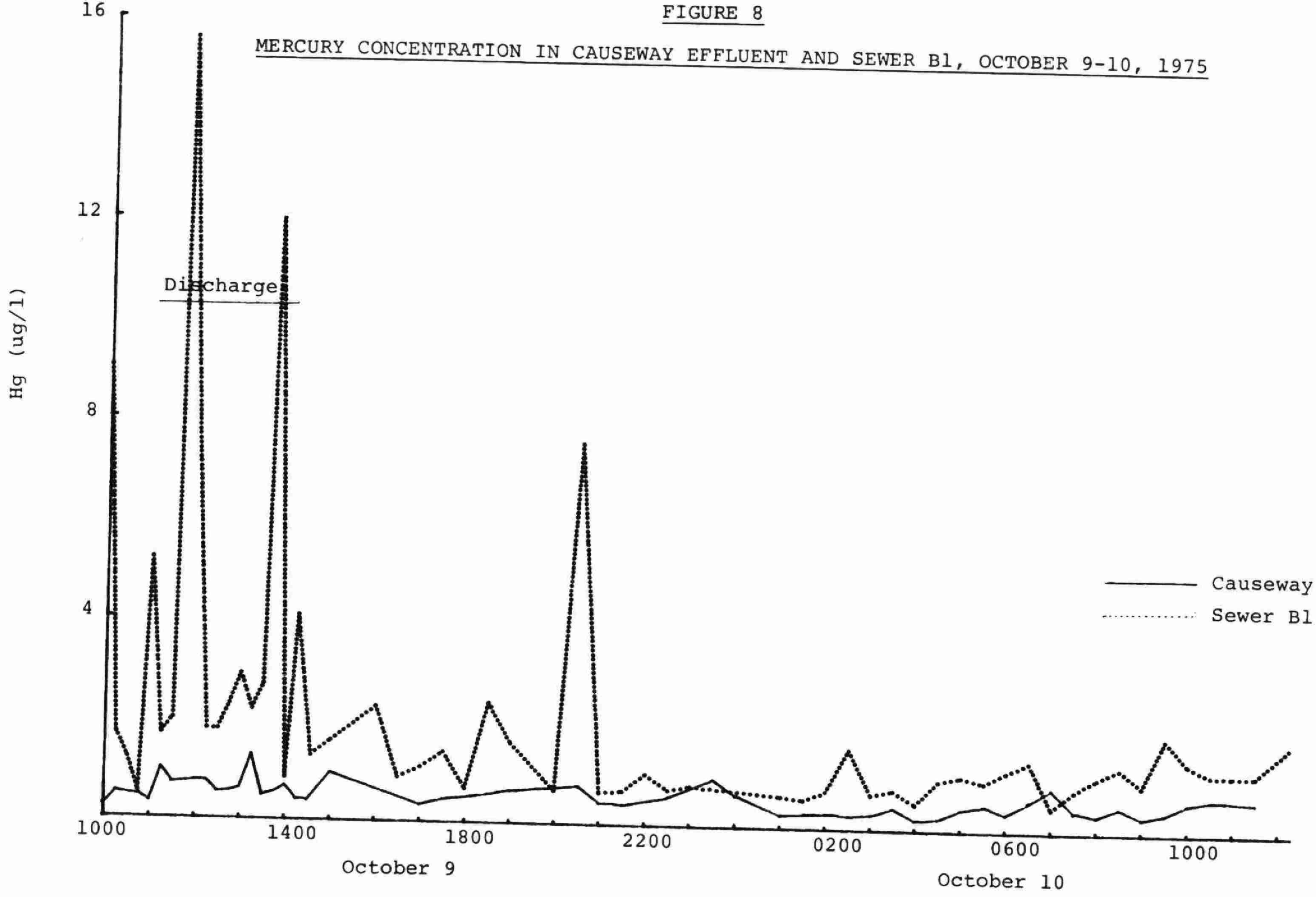


FIGURE 8

MERCURY CONCENTRATION IN CAUSEWAY EFFLUENT AND SEWER B1, OCTOBER 9-10, 1975



October 14:

Beginning at 1115 and ending at 1430, 73,000 Imperial gallons of treated effluent were discharged. During and immediately after this discharge, noticeable increases in the concentration of mercury in the causeway, sewer B1, and sewer D1 were observed. (see Fig. 11). Between midnight, October 13, and 1100, October 14, the mercury in the causeway averaged 0.73 ug/l, ranging from 0.27 to 3.39 ug/l. From 1115 to 1545, the mercury concentration averaged 2.8 ug/l, and reached a peak concentration of 7.6 ug/l at 1515. The concentration averaged 0.56 ug/l from 1515 to 2400 (see Fig. 9).

The mercury concentration in sewer B1 showed similar trends. Before 1100 on October 14, the average mercury level was 2.1 ug/l, while from 1115 to 1545, the average was 8.1 ug/l, falling to 1.4 ug/l from 1600 to 2400 (see Fig. 10).

The most noticeable increase in mercury concentration was in sewer D1, which rose from less than 6 ug/l prior to the discharge, attained a peak concentration of 129 ug/l at 1430, and fell to 19.3 ug/l by 1445 (see Fig. 11).

All samples taken on October 14 from sewers B2, C, D, E, F, G, H, and the east and west headers had mercury concentrations less than 1 ug/l.

Fig. 12 shows mercury concentrations in the causeway effluent and sewer B1 for the period of this survey.

## II. SEDIMENTS AND PRODUCTS

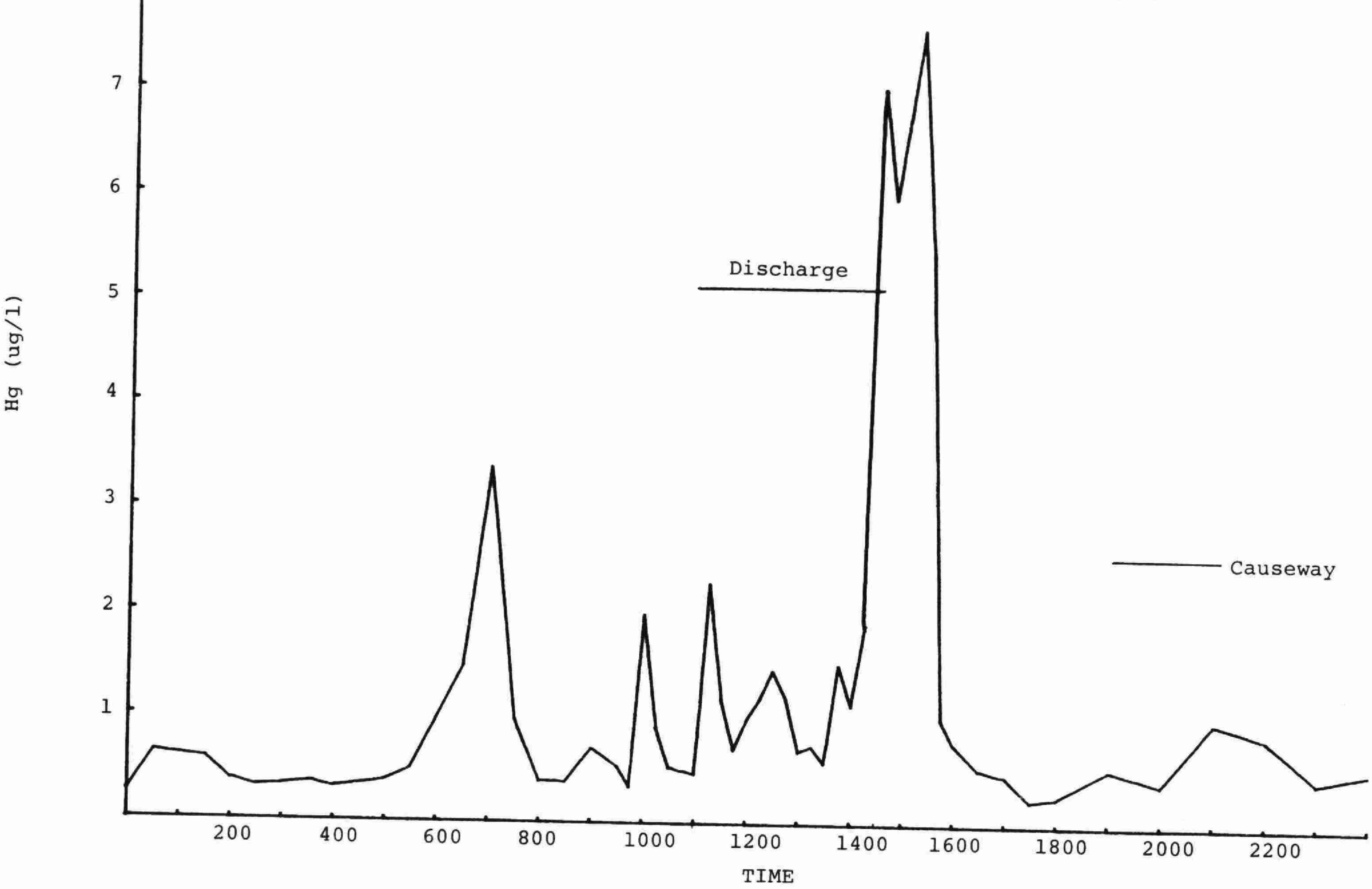
The analytical data for the sediments are attached in Appendix II.

### Causeway Sediments:

The mercury concentration in the causeway sediments ranged from 0.84 to 338 mg/kg. The higher concentrations of mercury in the top 2 cm of sediments are fairly well

FIGURE 9

MERCURY CONCENTRATION IN CAUSEWAY EFFLUENT, OCTOBER 14, 1975




October 14

FIGURE 10

MERCURY CONCENTRATION IN CAUSEWAY EFFLUENT, AND SEWER B1, OCTOBER 14, 1975

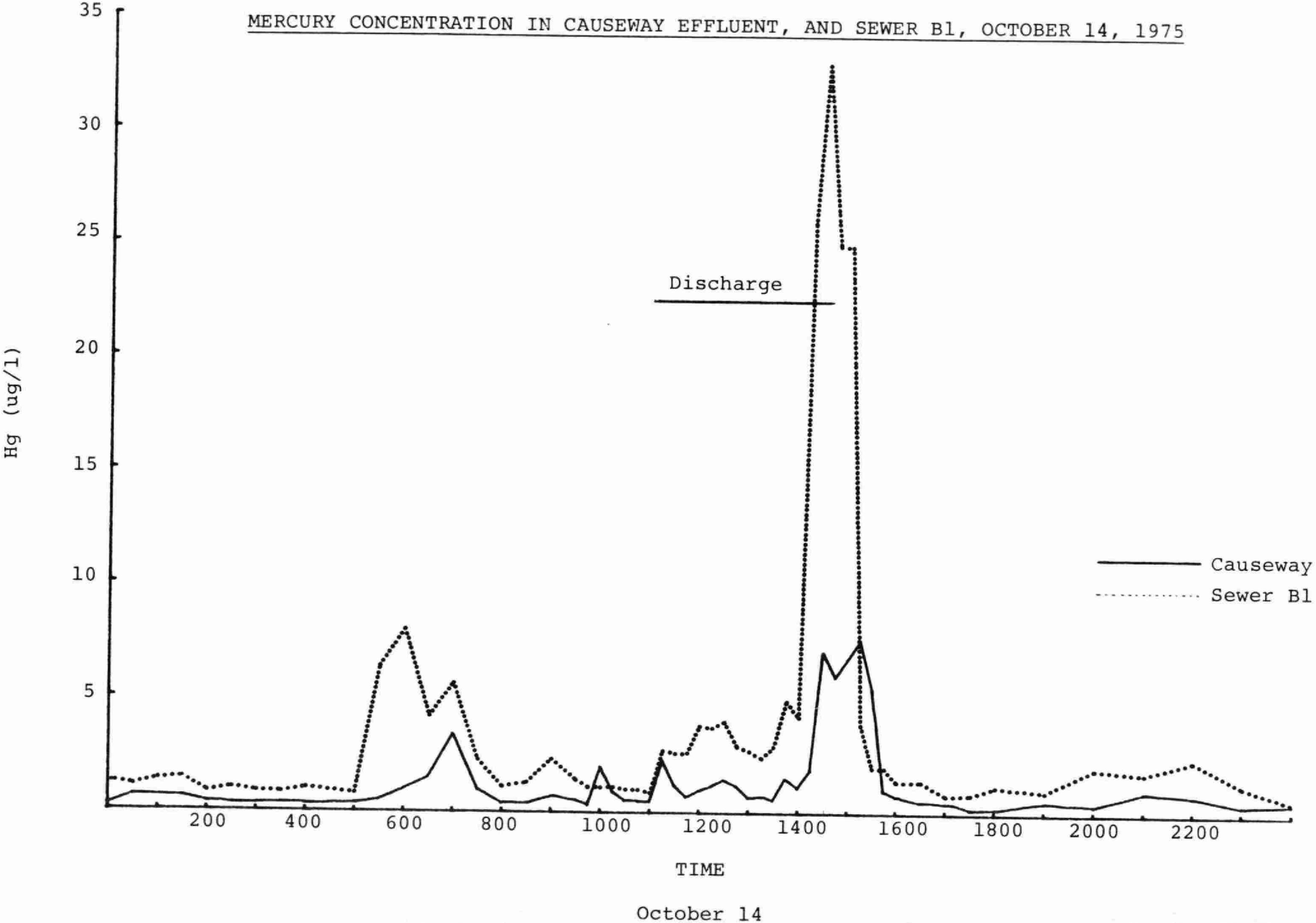


FIGURE 11

MERCURY CONCENTRATION IN CAUSEWAY EFFLUENT, SEWER B1, AND SEWER D1, OCTOBER 14, 1975

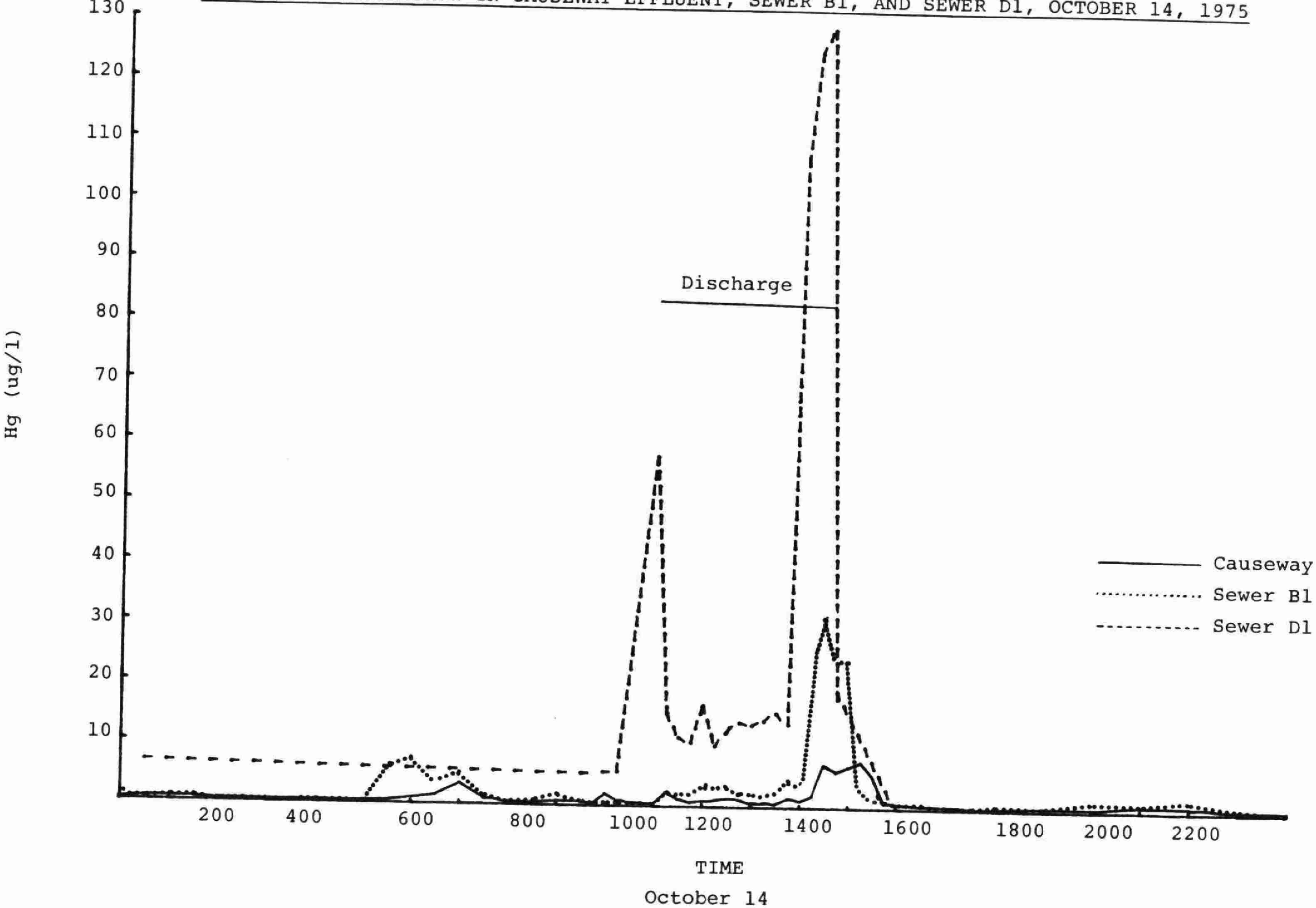
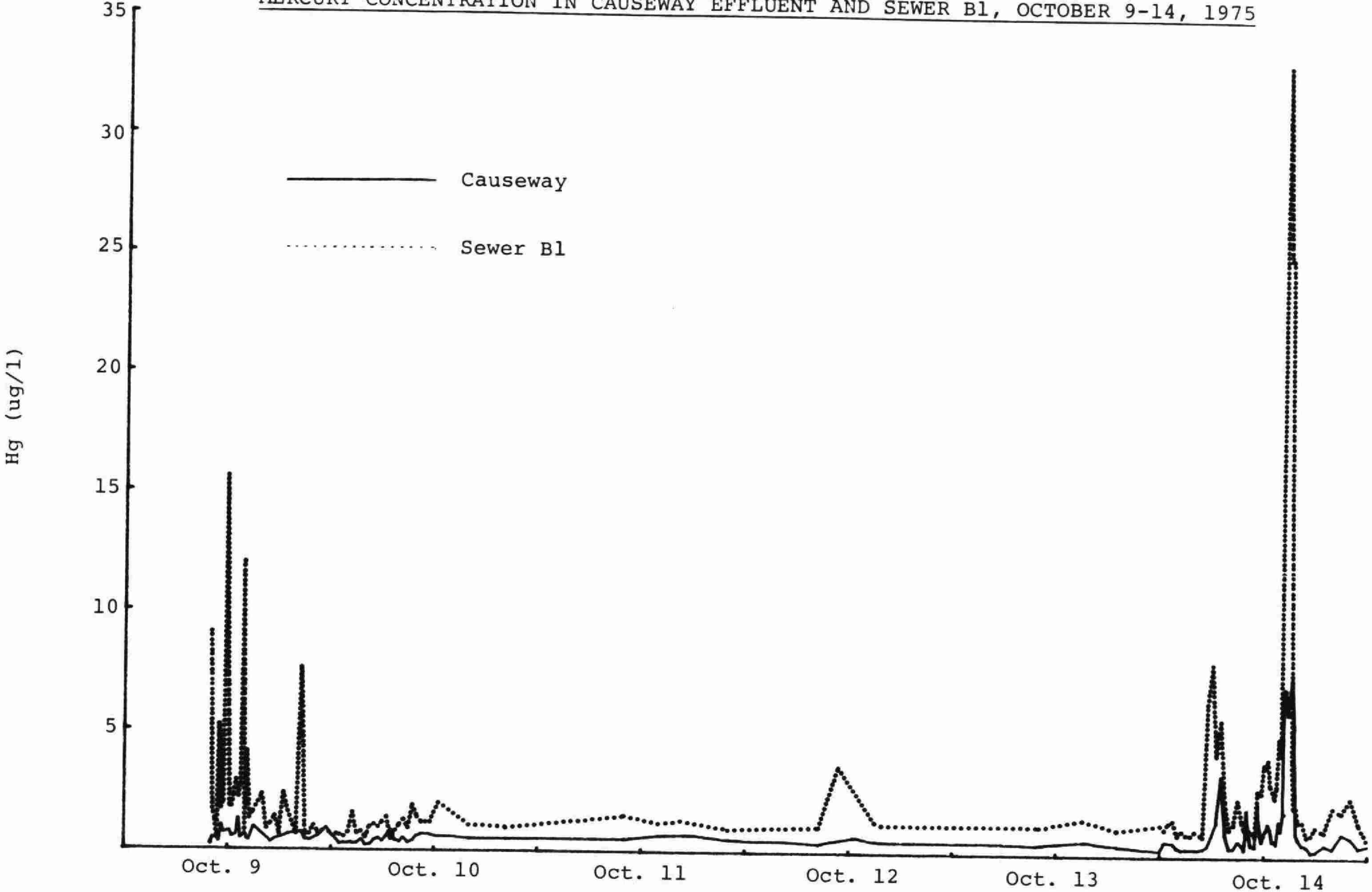


FIGURE 12

MERCURY CONCENTRATION IN CAUSEWAY EFFLUENT AND SEWER B1, OCTOBER 9-14, 1975



localized (see Fig. 6) opposite, and slightly downstream from sewers B1 and B2. There appear to be no consistent trends in the mercury concentrations in the cores from top to bottom, although the mercury level tends to be higher in the upper portion of the core.

Products:

The results of analyses of samples of paper from Reed Paper, and samples of various chemical products from Dryden Chemicals are attached in Appendix III.

Also attached in Appendix III are the results of filtered and unfiltered, preserved and unpreserved samples.

## DISCUSSION

### I. DATA INTERPRETATION

Several effluent samples were analyzed before and after filtering, and the results indicate that at least a portion of the mercury in the effluent is present as a particulate, presumably mercuric sulfide. Both particulate and dissolved mercury would be measured by the analytical methods used, but the presence of mercury associated with particles could cause difficulties in obtaining homogeneous samples. For example, if a particle of mercuric sulfide of 0.016 in. diameter were included in an 8 oz sample, the mercury concentration in the bottle would be 1000 ug/l.

Because of the heterogeneous nature of particles in an effluent, large variations in mercury concentration can occur, as can be seen by comparing the data for sewer D1 and the treatment tank discharge for October 14 (see page 19). For the mercury concentration at sewer D1 to be as high as 129 ug/l, the treatment tank discharge would theoretically have been as high as 359 ug/l, based on simple dilution ratios, but mercury results higher than 65 ug/l were not found. This could be due to the presence of particulate matter at the time of sampling. It should also be noted, however, that the samples taken at the end of the discharge were broken in transit to the laboratory so that the data for such an assumption are not complete.

Another problem in the interpretation of the data is encountered in the statistical handling of analytical results less than the detection limit of the method. For example, many of the analyses of the contents of the east and west headers yielded results <0.05 ug/l. When using these results in averaging and for calculating mercury loadings, the following method has been used: the number is reported, using the value 0.025 ug/l as an estimate of each result <0.05 ug/l, followed by a range, using 0.00 ug/l and 0.05 ug/l as minimum and maximum estimates. Using this method, the average

concentration in the east header would be 0.11 ug/l (0.09 - 0.13).

## II. EFFLUENTS

The mercury concentration in the causeway was quite different for the two discharges of treated effluent. The first discharge, had quite a small volume (25,850 gal.) some of which had already been released by the time sampling was started. Sewer B1 showed rapid fluctuations in its mercury concentration, but the level in the causeway was not increased significantly.

During the second batch discharge, however, a well-defined peak in mercury concentration appeared in both sewer B1 and in the causeway. The peak appeared to coincide with the last portion of discharge, and was clearly noticeable in sewer D1.

The fact that the increase occurred towards the end of the discharge might suggest that the solids at the bottom of the treatment tank were disturbed as the level of the tank contents descended, and this is substantiated by the above-mentioned tests which indicated that some of the mercury was associated with particulates. However, the coincident rises in mercury concentration in sewers D1, B1, and the causeway suggest the presence of at least some dissolved mercury, or very finely divided, mobile particulate matter consisting of or including, mercury precipitate.

Once the effluent enters the causeway, the mercury deposition pattern in the sediments suggests that some of the particulate mercury settles out close to the point of discharge (Fig. 6). There is also the possibility that some dissolved mercury may be adsorbed on sediments. The very northerly portion of the causeway has apparently been scoured of much of the mercury-laden sediments by the force of the flow from sewers B1 and B2.

The presence of these mercury-containing deposits on the

bottom of the causeway probably contributes to the fluctuations in the mercury concentration in the causeway since very small particles being swept through the causeway from sediment deposits can seriously affect the mercury concentration in grab samples taken further down the causeway.

Dryden Chemicals estimate the amount of mercury released during the discharge by analyzing either a grab sample from the tap on the draining line, or a grab from a "compositing" bucket below this tap. In the case of the latter, a small volume is allowed to drain continuously during a discharge. It would appear that neither of these techniques is completely satisfactory. The first method might yield unrepresentative results because the concentration of mercury in the treated effluent can vary considerably in a short time span. In the second method, the effluent is allowed to sit, unpreserved, until analysis. The results of the comparison between preserved and unpreserved samples indicate that preservation is required for satisfactory mercury results. In addition, there is the chance of significant contamination from the air when samples are left exposed. Nonetheless, acceptable agreement was obtained between the results reported by Dryden Chemicals and the average concentration derived from several MOE analyses.

The contents of the treatment tank do not represent the only mercury outputs from Dryden Chemicals. The total effluent from the plant, through the east header, amounts to $1.5 \times 10^6$ gallons/day (based on company figures). Although under certain operating conditions the west header discharge of $1.35 \times 10^6$ gallons/day can be diverted via sewers directly to the causeway, it is normally routed to Reed Paper for use in their processes. The water then enters the causeway through other sewers.

In addition, contributions to the mercury concentration in the causeway are made through the use of mercury containing products by Reed Paper. Using the results

of the analysis of several of the products of Dryden Chemicals, these inputs can be estimated:

- the contents of the east header averaged 0.11 ug/l (0.09 - 0.13), so with a flow of 1.5 x $10^6$ gal/day, 0.0016 lb (0.0014 - 0.0019) of mercury per day enters the causeway.

- the west header water also enters the causeway after its use in Reed Paper. The west header averaged 0.07 ug/l (0.06-0.09), so with a flow of 1.35 x $10^6$ gal/day, 0.0010 lb (0.0008 - 0.0012) of mercury enters the causeway via the west header.

- from October 5 to October 14, the chlorine production averaged 32.5 tons/day, or 28.8 tons of caustic. It is estimated that 55% of the caustic is used by Reed Paper. Analyses of the caustic (about 50% in solution) for mercury averaged 106 ug/l, so an additional 0.0045 lb/day could have been contributed by the caustic.

- approximately 11 tons of "hypo" solution are produced daily, all of which go to Reed Paper. At a mercury concentration of 140 ug/l, this could contribute 0.0031 lb/day.

- the hydrochloric acid that was analyzed had a mercury concentration 2600 ug/l. About six tons/day are produced, so this could add another 0.0312 lb/day to the total mercury output.

Summing these contributions yields 0.0414 (0.0410 - 0.0419) lb/day, as an estimate of the amount of mercury entering the Wabigoon River daily from Dryden Chemicals and Reed Paper, exclusive of contributions from the discharge of treatment tank contents, and assuming that none of the mercury in these products is lost to the air. To facilitate comparison with mercury loadings derived from the average daily causeway mercury concentration (see Table 1), contributions from background water should be considered. The remaining 28 million gallons per day of effluent from the chlor-alkali plant comes from filtered Wabigoon

TABLE I

ESTIMATES OF THE TOTAL MERCURY LOADING TO THE WABIGOON RIVER

| Date | *Calculation I (lb/day) | Calculation II (lb/day) | Calculation III (lb/day) |
|---|---|---|---|
| October 9 | 0.07 | 0.1283(0.1199-0.1358) | 0.189 |
| October 10 | 0 | 0.0484(0.0410-0.0559) | 0.142 |
| October 11 | 0 | 0.0484(0.0410-0.0559) | 0.192 |
| October 12 | 0 | 0.0484(0.0410-0.0559) | 0.157 |
| October 13 | 0 | 0.0484(0.0410-0.0559) | 0.132 |
| October 14 | 0.02 | 0.0757(0.0682-0.0832) | 0.456 |

* Calculation I: Mercury release reported by Dryden Chemical, based on one analysis of treatment tank contents.

Calculation II: Mercury loading estimated from separate analyses of caustic, hypo, hydrochloric acid and multiple analyses of the east and west headers, the treatment tank contents, and service water.

Calculation III: Mercury loading estimated from the analysis of between 4 and 54 samples per day of the causeway effluent. This is considered to be the most accurate estimate of the total amount of mercury entering the Wabigoon River through the causeway, although a portion of the mercury measured here is probably contributed from scouring of mercury-containing deposits in causeway sediments.

River water. After filtration, this "service water" almost invariably has a concentration of <0.05 ug/l, so could contribute 0.0070 lb/day (0.000 - 0.0140) to the observed loading. Adding this to the calculated 0.0414 (0.0410 - 0.0419) lb/day entering the causeway from potential inputs, an estimate (see Calculation II, Table 1) of the mercury entering the Wabigoon River through the causeway can be made. Comparing these calculated loadings with estimates obtained from the average concentration of mercury in the causeway effluent (see Calculation III, Table 1) it can be seen that Calculation II does not account for all of the mercury entering the Wabigoon River.

Since the calculations indicate that the mercury being released from the Reed Paper/Dryden Chemicals complex exceeds that of the chlor-alkali plant alone, it is apparent that some mercury arises from the use of mercury-contaminated products in the pulp and paper mill and a portion is probably contributed from mercury-containing deposits in causeway sediments.

## III. MISCELLANEOUS

The sediments at the bottom of the causeway contain significant amounts of mercury, and the sediments containing most mercury appear to be fairly localized. An estimation of the amount of mercury in these sediments, however, would require a more extensive core sampling survey.

A conclusion reached in the previous survey that a significant amount of the mercury in the effluent was associated with particulates was borne out. In every case, analysis of filtered and unfiltered aliquots of the same sample showed a significant decrease in the mercury concentration of the filtered portion. A greater proportion of the mercury was associated with particulates if the sample was taken closer to the treatment tank discharge pipe (see Appendix III).

In conjunction with the survey, a study was carried

out concerning the preservation of samples. When taking samples for mercury analysis, Dryden Chemical does not add preservatives. Several samples were taken with and without preservatives, and a comparison of the two sets of results shows that the unpreserved samples yielded lower results. Preservation of samples could appear to be necessary for the accurate analysis of mercury in aqueous solution.

CONCLUSIONS:

1) The best estimate of the amount of mercury entering the Wabigoon River River from the Dryden chlor-alkali/ pulp and paper complex ranged from 0.13 lb/day to 0.46 lb/day during the period October 9-14, 1975.

2) The amount of mercury discharged by Dryden Chemicals accounted for only a portion of the total amount of mercury entering the Wabigoon River at the Dryden chlor-alkali/pulp and paper complex;

3) Significant contributions to the total amount of mercury entering the Wabigoon River are made by waste discharges from Reed Paper;

4) There are significant amounts of mercury in the sediment at the bottom of the causeway. Scouring of these sediment contributed to the observed mercury concentrations in the total causeway effluent;

5) A portion of the mercury in the effluents is associated with particulates;

6) Preservation of samples is necessary for the accurate analysis of mercury in industrial effluents.

# APPENDIX I

## EFFLUENT DATA

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Causeway | October 9 | 1000 | 0.26 |
| Causeway | October 9 | 1015 | 0.51 |
| Causeway | October 9 | 1045 | 0.46 |
| Causeway | October 9 | 1100 | 0.33 |
| Causeway | October 9 | 1115 | 1.00 |
| Causeway | October 9 | 1130 | 0.72 |
| Causeway | October 9 | 1200 | 0.76 |
| Causeway | October 9 | 1215 | 0.75 |
| Causeway | October 9 | 1230 | 0.54 |
| Causeway | October 9 | 1245 | 0.56 |
| Causeway | October 9 | 1300 | 0.62 |
| Causeway | October 9 | 1315 | 1.30 |
| Causeway | October 9 | 1330 | 0.49 |
| Causeway | October 9 | 1345 | 0.56 |
| Causeway | October 9 | 1400 | 0.68 |
| Causeway | October 9 | 1415 | 0.42 |
| Causeway | October 9 | 1430 | 0.39 |
| Causeway | October 9 | 1500 | 0.95 |
| Causeway | October 9 | 1700 | 0.35 |
| Causeway | October 9 | 1730 | 0.46 |
| Causeway | October 9 | 1830 | 0.58 |
| Causeway | October 9 | 1900 | 0.66 |
| Causeway | October 9 | 2030 | 0.77 |
| Causeway | October 9 | 2100 | 0.44 |
| Causeway | October 9 | 2130 | 0.41 |
| Causeway | October 9 | 2230 | 0.58 |
| Causeway | October 9 | 2330 | 0.95 |
| Causeway | October 9 | 2400 | 0.64 |
| Causeway | October 10 | 100 | 0.28 |
| Causeway | October 10 | 130 | 0.30 |
| Causeway | October 10 | 200 | 0.32 |
| Causeway | October 10 | 230 | 0.28 |
| Causeway | October 10 | 300 | 0.32 |
| Causeway | October 10 | 330 | 0.45 |
| Causeway | October 10 | 400 | 0.23 |
| Causeway | October 10 | 430 | 0.26 |
| Causeway | October 10 | 500 | 0.45 |
| Causeway | October 10 | 530 | 0.53 |
| Causeway | October 10 | 600 | 0.37 |
| Causeway | October 10 | 630 | 0.61 |
| Causeway | October 10 | 700 | 0.88 |
| Causeway | October 10 | 730 | 0.44 |
| Causeway | October 10 | 800 | 0.36 |
| Causeway | October 10 | 830 | 0.53 |
| Causeway | October 10 | 900 | 0.34 |
| Causeway | October 10 | 930 | 0.42 |
| Causeway | October 10 | 1000 | 0.63 |
| Causeway | October 10 | 1030 | 0.71 |
| Causeway | October 10 | 1130 | 0.66 |
| Causeway | October 10 | 1230 | 0.60 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Causeway | October 10 | 1600 | 0.52 |
| Causeway | October 10 | 2020 | 0.52 |
| Causeway | October 11 | 1000 | 0.52 |
| Causeway | October 11 | 1400 | 0.69 |
| Causeway | October 11 | 1651 | 0.74 |
| Causeway | October 11 | 2200 | 0.53 |
| Causeway | October 12 | 830 | 0.39 |
| Causeway | October 12 | 1230 | 0.66 |
| Causeway | October 12 | 1500 | 0.50 |
| Causeway | October 12 | 1545 | 0.47 |
| Causeway | October 13 | 930 | 0.42 |
| Causeway | October 13 | 1500 | 0.59 |
| Causeway | October 13 | 1900 | 0.42 |
| Causeway | October 13 | 2400 | 0.27 |
| Causeway | October 14 | 30 | 0.64 |
| Causeway | October 14 | 130 | 0.59 |
| Causeway | October 14 | 200 | 0.38 |
| Causeway | October 14 | 230 | 0.32 |
| Causeway | October 14 | 300 | 0.34 |
| Causeway | October 14 | 330 | 0.37 |
| Causeway | October 14 | 400 | 0.32 |
| Causeway | October 14 | 500 | 0.39 |
| Causeway | October 14 | 530 | 0.50 |
| Causeway | October 14 | 630 | 1.49 |
| Causeway | October 14 | 700 | 3.39 |
| Causeway | October 14 | 730 | 0.98 |
| Causeway | October 14 | 800 | 0.39 |
| Causeway | October 14 | 830 | 0.38 |
| Causeway | October 14 | 900 | 0.71 |
| Causeway | October 14 | 930 | 0.54 |
| Causeway | October 14 | 945 | 0.34 |
| Causeway | October 14 | 1000 | 2.00 |
| Causeway | October 14 | 1015 | 0.92 |
| Causeway | October 14 | 1030 | 0.53 |
| Causeway | October 14 | 1045 | 0.50 |
| Causeway | October 14 | 1100 | 0.47 |
| Causeway | October 14 | 1115 | 2.30 |
| Causeway | October 14 | 1130 | 1.20 |
| Causeway | October 14 | 1145 | 0.71 |
| Causeway | October 14 | 1200 | 1.00 |
| Causeway | October 14 | 1215 | 1.20 |
| Causeway | October 14 | 1230 | 1.47 |
| Causeway | October 14 | 1245 | 1.21 |
| Causeway | October 14 | 1300 | 0.70 |
| Causeway | October 14 | 1315 | 0.75 |
| Causeway | October 14 | 1330 | 0.59 |
| Causeway | October 14 | 1345 | 1.53 |
| Causeway | October 14 | 1400 | 1.14 |
| Causeway | October 14 | 1415 | 1.90 |
| Causeway | October 14 | 1430 | 7.05 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Causeway | October 14 | 1430 | 7.05 |
| Causeway | October 14 | 1445 | 6.00 |
| Causeway | October 14 | 1500 | 6.78 |
| Causeway | October 14 | 1515 | 7.63 |
| Causeway | October 14 | 1530 | 5.47 |
| Causeway | October 14 | 1545 | 1.02 |
| Causeway | October 14 | 1600 | 0.78 |
| Causeway | October 14 | 1630 | 0.54 |
| Causeway | October 14 | 1700 | 0.48 |
| Causeway | October 14 | 1730 | 0.25 |
| Causeway | October 14 | 1800 | 0.28 |
| Causeway | October 14 | 1900 | 0.55 |
| Causeway | October 14 | 2000 | 0.41 |
| Causeway | October 14 | 2100 | 1.01 |
| Causeway | October 14 | 2200 | 0.86 |
| Causeway | October 14 | 2300 | 0.45 |
| Causeway | October 14 | 2400 | 0.55 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Sewer B1 | October 9 | 1000 | 9.10 |
| Sewer B1 | October 9 | 1015 | 1.70 |
| Sewer B1 | October 9 | 1030 | 1.20 |
| Sewer B1 | October 9 | 1045 | 0.53 |
| Sewer B1 | October 9 | 1100 | 5.20 |
| Sewer B1 | October 9 | 1115 | 1.70 |
| Sewer B1 | October 9 | 1130 | 2.00 |
| Sewer B1 | October 9 | 1145 | 15.60 |
| Sewer B1 | October 9 | 1200 | 7.20 |
| Sewer B1 | October 9 | 1215 | 1.80 |
| Sewer B1 | October 9 | 1230 | 1.80 |
| Sewer B1 | October 9 | 1245 | 2.30 |
| Sewer B1 | October 9 | 1300 | 2.90 |
| Sewer B1 | October 9 | 1315 | 2.20 |
| Sewer B1 | October 9 | 1330 | 2.70 |
| Sewer B1 | October 9 | 1345 | 12.00 |
| Sewer B1 | October 9 | 1400 | 0.84 |
| Sewer B1 | October 9 | 1415 | 4.10 |
| Sewer B1 | October 9 | 1434 | 1.30 |
| Sewer B1 | October 9 | 1500 | 1.60 |
| Sewer B1 | October 9 | 1600 | 2.30 |
| Sewer B1 | October 9 | 1630 | 0.89 |
| Sewer B1 | October 9 | 1700 | 1.10 |
| Sewer B1 | October 9 | 1730 | 1.40 |
| Sewer B1 | October 9 | 1800 | 0.68 |
| Sewer B1 | October 9 | 1830 | 2.40 |
| Sewer B1 | October 9 | 1900 | 1.60 |
| Sewer B1 | October 9 | 2000 | 0.67 |
| Sewer B1 | October 9 | 2030 | 7.60 |
| Sewer B1 | October 9 | 2100 | 0.65 |
| Sewer B1 | October 9 | 2130 | 0.68 |
| Sewer B1 | October 9 | 2200 | 1.03 |
| Sewer B1 | October 9 | 2230 | 0.73 |
| Sewer B1 | October 9 | 2300 | 0.80 |
| Sewer B1 | October 10 | 100 | 0.64 |
| Sewer B1 | October 10 | 130 | 0.58 |
| Sewer B1 | October 10 | 200 | 0.76 |
| Sewer B1 | October 10 | 230 | 1.60 |
| Sewer B1 | October 10 | 300 | 0.71 |
| Sewer B1 | October 10 | 330 | 0.80 |
| Sewer B1 | October 10 | 400 | 0.54 |
| Sewer B1 | October 10 | 430 | 1.00 |
| Sewer B1 | October 10 | 500 | 1.10 |
| Sewer B1 | October 10 | 530 | 0.98 |
| Sewer B1 | October 10 | 600 | 1.20 |
| Sewer B1 | October 10 | 630 | 1.40 |
| Sewer B1 | October 10 | 700 | 0.49 |
| Sewer B1 | October 10 | 730 | 0.84 |
| Sewer B1 | October 10 | 800 | 1.10 |
| Sewer B1 | October 10 | 830 | 1.30 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Sewer B1 | October 10 | 900 | 0.95 |
| Sewer B1 | October 10 | 930 | 1.90 |
| Sewer B1 | October 10 | 1000 | 1.40 |
| Sewer B1 | October 10 | 1030 | 1.20 |
| Sewer B1 | October 10 | 1100 | 1.20 |
| Sewer B1 | October 10 | 1130 | 1.20 |
| Sewer B1 | October 10 | 1230 | 2.00 |
| Sewer B1 | October 10 | 1600 | 1.10 |
| Sewer B1 | October 10 | 2020 | 1.00 |
| Sewer B1 | October 11 | 1000 | 1.50 |
| Sewer B1 | October 11 | 1400 | 1.20 |
| Sewer B1 | October 11 | 1630 | 1.30 |
| Sewer B1 | October 11 | 2200 | 0.98 |
| Sewer B1 | October 12 | 830 | 1.10 |
| Sewer B1 | October 12 | 1045 | 3.60 |
| Sewer B1 | October 12 | 1500 | 1.30 |
| Sewer B1 | October 12 | 1545 | 1.20 |
| Sewer B1 | October 13 | 1000 | 1.20 |
| Sewer B1 | October 13 | 1500 | 1.50 |
| Sewer B1 | October 13 | 1900 | 1.10 |
| Sewer B1 | October 13 | 2400 | 1.33 |
| Sewer B1 | October 14 | 30 | 1.16 |
| Sewer B1 | October 14 | 100 | 1.43 |
| Sewer B1 | October 14 | 130 | 1.52 |
| Sewer B1 | October 14 | 200 | 0.91 |
| Sewer B1 | October 14 | 230 | 1.09 |
| Sewer B1 | October 14 | 300 | 0.94 |
| Sewer B1 | October 14 | 330 | 0.91 |
| Sewer B1 | October 14 | 400 | 1.09 |
| Sewer B1 | October 14 | 500 | 0.88 |
| Sewer B1 | October 14 | 530 | 6.43 |
| Sewer B1 | October 14 | 600 | 8.05 |
| Sewer B1 | October 14 | 630 | 4.24 |
| Sewer B1 | October 14 | 700 | 5.71 |
| Sewer B1 | October 14 | 730 | 2.34 |
| Sewer B1 | October 14 | 800 | 1.21 |
| Sewer B1 | October 14 | 830 | 1.38 |
| Sewer B1 | October 14 | 900 | 2.42 |
| Sewer B1 | October 14 | 930 | 1.50 |
| Sewer B1 | October 14 | 945 | 1.20 |
| Sewer B1 | October 14 | 1000 | 1.20 |
| Sewer B1 | October 14 | 1015 | 1.20 |
| Sewer B1 | October 14 | 1030 | 1.10 |
| Sewer B1 | October 14 | 1045 | 1.10 |
| Sewer B1 | October 14 | 1100 | 0.95 |
| Sewer B1 | October 14 | 1115 | 2.80 |
| Sewer B1 | October 14 | 1130 | 2.70 |
| Sewer B1 | October 14 | 1145 | 2.70 |
| Sewer B1 | October 14 | 1200 | 3.90 |
| Sewer B1 | October 14 | 1215 | 3.80 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Sewer B1 | October 14 | 1215 | 3.80 |
| Sewer B1 | October 14 | 1230 | 4.10 |
| Sewer B1 | October 14 | 1245 | 3.00 |
| Sewer B1 | October 14 | 1300 | 2.80 |
| Sewer B1 | October 14 | 1315 | 2.50 |
| Sewer B1 | October 14 | 1330 | 3.00 |
| Sewer B1 | October 14 | 1345 | 5.00 |
| Sewer B1 | October 14 | 1400 | 4.30 |
| Sewer B1 | October 14 | 1415 | 26.00 |
| Sewer B1 | October 14 | 1430 | 33.00 |
| Sewer B1 | October 14 | 1445 | 25.00 |
| Sewer B1 | October 14 | 1500 | 25.00 |
| Sewer B1 | October 14 | 1515 | 4.00 |
| Sewer B1 | October 14 | 1530 | 2.10 |
| Sewer B1 | October 14 | 1545 | 2.10 |
| Sewer B1 | October 14 | 1600 | 1.50 |
| Sewer B1 | October 14 | 1630 | 1.50 |
| Sewer B1 | October 14 | 1700 | 0.91 |
| Sewer B1 | October 14 | 1730 | 0.96 |
| Sewer B1 | October 14 | 1800 | 1.30 |
| Sewer B1 | October 14 | 1900 | 1.10 |
| Sewer B1 | October 14 | 2000 | 2.10 |
| Sewer B1 | October 14 | 2100 | 1.90 |
| Sewer B1 | October 14 | 2200 | 2.50 |
| Sewer B1 | October 14 | 2300 | 1.40 |
| Sewer B1 | October 14 | 2400 | 0.72 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Sewer B2 | October 9 | 1007 | 0.44 |
| Sewer B2 | October 9 | 1048 | 0.73 |
| Sewer B2 | October 9 | 1120 | 0.16 |
| Sewer B2 | October 9 | 1205 | 0.16 |
| Sewer B2 | October 9 | 1245 | 0.34 |
| Sewer B2 | October 9 | 1330 | <0.05 |
| Sewer B2 | October 10 | 1100 | 0.37 |
| Sewer B2 | October 10 | 1640 | 0.17 |
| Sewer B2 | October 11 | 1000 | 0.64 |
| Sewer B2 | October 11 | 1632 | 0.40 |
| Sewer B2 | October 12 | 1100 | 0.31 |
| Sewer B2 | October 12 | 1505 | 0.07 |
| Sewer B2 | October 13 | 1500 | 0.08 |
| Sewer B2 | October 13 | 1900 | 0.17 |
| Sewer B2 | October 14 | 900 | 0.05 |
| Sewer B2 | October 14 | 945 | 0.19 |
| Sewer B2 | October 14 | 1045 | 0.05 |
| Sewer B2 | October 14 | 1200 | 0.12 |
| Sewer B2 | October 14 | 1300 | 0.34 |
| Sewer B2 | October 14 | 1500 | 0.05 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Sewer C | October 9 | 1011 | <0.05 |
| Sewer C | October 9 | 1125 | <0.05 |
| Sewer C | October 9 | 1208 | 0.27 |
| Sewer C | October 10 | 1100 | 0.83 |
| Sewer C | October 11 | 1000 | 0.05 |
| Sewer C | October 11 | 1635 | 0.05 |
| Sewer C | October 12 | 1045 | 1.50 |
| Sewer C | October 12 | 1510 | 0.08 |
| Sewer C | October 14 | 900 | 0.05 |
| Sewer C | October 14 | 945 | 0.05 |
| Sewer C | October 14 | 1100 | 0.05 |
| Sewer C | October 14 | 1200 | 0.05 |
| Sewer C | October 14 | 1300 | 0.05 |
| Sewer C | October 14 | 1500 | 0.05 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Sewer D | October 9 | 1018 | 0.32 |
| Sewer D | October 9 | 1107 | 0.62 |
| Sewer D | October 9 | 1148 | 0.52 |
| Sewer D | October 9 | 1233 | 0.21 |
| Sewer D | October 9 | 1319 | 0.44 |
| Sewer D | October 9 | 1620 | 0.40 |
| Sewer D | October 10 | 1645 | 0.26 |
| Sewer D | October 11 | 1000 | 0.20 |
| Sewer D | October 11 | 1640 | 0.61 |
| Sewer D | October 12 | 1100 | 0.17 |
| Sewer D | October 12 | 1515 | 0.20 |
| Sewer D | October 13 | 1500 | 0.37 |
| Sewer D | October 13 | 1900 | 0.25 |
| Sewer D | October 14 | 900 | 0.31 |
| Sewer D | October 14 | 945 | 0.60 |
| Sewer D | October 14 | 1100 | 0.27 |
| Sewer D | October 14 | 1200 | 0.50 |
| Sewer D | October 14 | 1300 | 0.47 |
| Sewer D | October 14 | 1500 | 0.41 |

| Location | Date | Time | Hg(ug/1) |
|---|---|---|---|
| Sewer E | October 9 | 1109 | 0.15 |
| Sewer E | October 9 | 1151 | 0.40 |
| Sewer E | October 9 | 1236 | 0.50 |
| Sewer E | October 9 | 1322 | 0.86 |
| Sewer E | October 9 | 1620 | 0.26 |
| Sewer E | October 10 | 1100 | 1.00 |
| Sewer E | October 10 | 1647 | 0.58 |
| Sewer E | October 11 | 1000 | 0.41 |
| Sewer E | October 11 | 1643 | 0.38 |
| Sewer E | October 12 | 1100 | 0.08 |
| Sewer E | October 12 | 1520 | 0.19 |
| Sewer E | October 13 | 1500 | 0.85 |
| Sewer E | October 13 | 1900 | 0.13 |
| Sewer E | October 14 | 900 | 0.30 |
| Sewer E | October 14 | 945 | 0.33 |
| Sewer E | October 14 | 1100 | 0.16 |
| Sewer E | October 14 | 1200 | 0.16 |
| Sewer E | October 14 | 1300 | 0.60 |
| Sewer E | October 14 | 1500 | 0.36 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Sewer F | October 9 | 1025 | 0.62 |
| Sewer F | October 9 | 1111 | 0.73 |
| Sewer F | October 9 | 1238 | 0.57 |
| Sewer F | October 9 | 1322 | 0.55 |
| Sewer F | October 9 | 1625 | 0.36 |
| Sewer F | October 10 | 1648 | 0.79 |
| Sewer F | October 11 | 1000 | 0.17 |
| Sewer F | October 11 | 1644 | 0.77 |
| Sewer F | October 12 | 1100 | 0.22 |
| Sewer F | October 12 | 1525 | 0.24 |
| Sewer F | October 13 | 1500 | 0.05 |
| Sewer F | October 13 | 1900 | 0.28 |
| Sewer F | October 14 | 900 | 0.24 |
| Sewer F | October 14 | 945 | 0.32 |
| Sewer F | October 14 | 1100 | 0.63 |
| Sewer F | October 14 | 1200 | 0.25 |
| Sewer F | October 14 | 1300 | 0.48 |
| Sewer F | October 14 | 1500 | 0.47 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Sewer G | October 9 | 1020 | 0.81 |
| Sewer G | October 9 | 1112 | 0.40 |
| Sewer G | October 9 | 1155 | 0.39 |
| Sewer G | October 9 | 1240 | 0.29 |
| Sewer G | October 9 | 1323 | 0.55 |
| Sewer G | October 9 | 1627 | 0.13 |
| Sewer G | October 10 | 1100 | 0.64 |
| Sewer G | October 10 | 1650 | 0.38 |
| Sewer G | October 11 | 1000 | 0.25 |
| Sewer G | October 12 | 1115 | 0.22 |
| Sewer G | October 12 | 1525 | 0.23 |
| Sewer G | October 13 | 1900 | 0.16 |
| Sewer G | October 14 | 900 | 0.21 |
| Sewer G | October 14 | 945 | 0.19 |
| Sewer G | October 14 | 1100 | 0.27 |
| Sewer G | October 14 | 1200 | 0.20 |
| Sewer G | October 14 | 1300 | 0.27 |
| Sewer G | October 14 | 1500 | 0.30 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Sewer H | October 9 | 1000 | 0.20 |
| Sewer H | October 9 | 1015 | 0.16 |
| Sewer H | October 9 | 1030 | 0.10 |
| Sewer H | October 9 | 1100 | 0.06 |
| Sewer H | October 9 | 1130 | 0.06 |
| Sewer H | October 9 | 1200 | 0.12 |
| Sewer H | October 9 | 1230 | 0.18 |
| Sewer H | October 9 | 1300 | 0.11 |
| Sewer H | October 9 | 1330 | 0.20 |
| Sewer H | October 9 | 1400 | 0.13 |
| Sewer H | October 9 | 1600 | 0.10 |
| Sewer H | October 10 | 1100 | 0.62 |
| Sewer H | October 10 | 1645 | 0.09 |
| Sewer H | October 11 | 1000 | 0.08 |
| Sewer H | October 11 | 1648 | 0.38 |
| Sewer H | October 12 | 1130 | 0.07 |
| Sewer H | October 12 | 1530 | 0.13 |
| Sewer H | October 13 | 1500 | 0.17 |
| Sewer H | October 14 | 900 | 0.07 |
| Sewer H | October 14 | 945 | 0.20 |
| Sewer H | October 14 | 1100 | 0.12 |
| Sewer H | October 14 | 1200 | 0.25 |
| Sewer H | October 14 | 1300 | 0.24 |
| Sewer H | October 14 | 1500 | 0.05 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Treatment Tank | October 9 | 1055 | 28.00 |
| Treatment Tank | October 9 | 1105 | 26.00 |
| Treatment Tank | October 9 | 1120 | 30.00 |
| Treatment Tank | October 9 | 1135 | 26.00 |
| Treatment Tank | October 9 | 1150 | 23.00 |
| Treatment Tank | October 9 | 1205 | 23.00 |
| Treatment Tank | October 9 | 1220 | 25.00 |
| Treatment Tank | October 9 | 1235 | 65.00 |
| Treatment Tank | October 9 | 1250 | 1000.00 |
| Treatment Tank | October 9 | 1305 | 1800.00 |
| Treatment Tank | October 14 | 1100 | 9.70 |
| Treatment Tank | October 14 | 1130 | 27.20 |
| Treatment Tank | October 14 | 1145 | 29.90 |
| Treatment Tank | October 14 | 1200 | 51.70 |
| Treatment Tank | October 14 | 1345 | 65.70 |
| Treatment Tank | October 14 | 1400 | 40.20 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| East Header | October 9 | 1005 | < 0.05 |
| East Header | October 9 | 1020 | < 0.05 |
| East Header | October 9 | 1035 | < 0.05 |
| East Header | October 9 | 1050 | < 0.05 |
| East Header | October 9 | 1105 | < 0.05 |
| East Header | October 9 | 1120 | < 0.05 |
| East Header | October 9 | 1135 | < 0.05 |
| East Header | October 9 | 1150 | < 0.05 |
| East Header | October 9 | 1205 | < 0.05 |
| East Header | October 9 | 1220 | < 0.05 |
| East Header | October 9 | 1235 | < 0.05 |
| East Header | October 9 | 1250 | < 0.05 |
| East Header | October 9 | 1305 | < 0.05 |
| East Header | October 9 | 1320 | < 0.05 |
| East Header | October 9 | 1335 | < 0.05 |
| East Header | October 9 | 1350 | < 0.05 |
| East Header | October 9 | 1405 | < 0.05 |
| East Header | October 9 | 1420 | < 0.05 |
| East Header | October 9 | 1640 | < 0.05 |
| East Header | October 11 | 1640 | < 0.05 |
| East Header | October 12 | 1030 | < 0.05 |
| East Header | October 12 | 1650 | 0.22 |
| East Header | October 13 | 930 | 0.27 |
| East Header | October 14 | 915 | 0.62 |
| East Header | October 14 | 945 | 0.37 |
| East Header | October 14 | 1045 | 0.27 |
| East Header | October 14 | 1130 | 0.20 |
| East Header | October 14 | 1200 | 0.25 |
| East Header | October 14 | 1230 | 0.22 |
| East Header | October 14 | 1300 | 0.27 |

| Location | Date | Time | Hg(ug/1) |
|---|---|---|---|
| West Header | October 9 | 1005 | 0.10 |
| West Header | October 9 | 1023 | 0.06 |
| West Header | October 9 | 1035 | 0.20 |
| West Header | October 9 | 1040 | < 0.05 |
| West Header | October 9 | 1105 | < 0.05 |
| West Header | October 9 | 1120 | < 0.05 |
| West Header | October 9 | 1135 | < 0.05 |
| West Header | October 9 | 1150 | < 0.05 |
| West Header | October 9 | 1205 | < 0.05 |
| West Header | October 9 | 1220 | < 0.05 |
| West Header | October 9 | 1235 | < 0.05 |
| West Header | October 9 | 1250 | < 0.05 |
| West Header | October 9 | 1305 | < 0.05 |
| West Header | October 9 | 1320 | < 0.05 |
| West Header | October 9 | 1335 | < 0.05 |
| West Header | October 9 | 1350 | < 0.05 |
| West Header | October 9 | 1405 | < 0.05 |
| West Header | October 9 | 1420 | < 0.05 |
| West Header | October 9 | 1640 | < 0.05 |
| West Header | October 9 | 1640 | < 0.05 |
| West Header | October 11 | 1640 | < 0.05 |
| West Header | October 12 | 1030 | < 0.05 |
| West Header | October 12 | 1650 | 0.13 |
| West Header | October 13 | 930 | 0.27 |
| West Header | October 13 | 1500 | 0.09 |
| West Header | October 14 | 915 | 0.09 |
| West Header | October 14 | 945 | 0.16 |
| West Header | October 14 | 1045 | 0.09 |
| West Header | October 14 | 1130 | 0.07 |
| West Header | October 14 | 1200 | 0.07 |
| West Header | October 14 | 1230 | 0.30 |
| West Header | October 14 | 1300 | 0.17 |
| West Header | October 14 | 1400 | 0.12 |

| Location | Date | Time | Hg(ug/l) |
|---|---|---|---|
| Sewer D1 | October 9 | 1000 | 4.00 |
| Sewer D1 | October 9 | 1015 | 4.00 |
| Sewer D1 | October 9 | 1030 | 3.00 |
| Sewer D1 | October 9 | 1045 | 2.00 |
| Sewer D1 | October 9 | 1100 | 6.00 |
| Sewer D1 | October 9 | 1115 | 7.00 |
| Sewer D1 | October 9 | 1130 | 7.00 |
| Sewer D1 | October 9 | 1145 | 7.00 |
| Sewer D1 | October 9 | 1200 | 7.00 |
| Sewer D1 | October 9 | 1215 | 5.00 |
| Sewer D1 | October 9 | 1230 | 3.00 |
| Sewer D1 | October 9 | 1245 | 5.00 |
| Sewer D1 | October 9 | 1300 | 5.00 |
| Sewer D1 | October 9 | 1315 | 4.00 |
| Sewer D1 | October 9 | 1330 | 3.00 |
| Sewer D1 | October 9 | 1345 | 3.00 |
| Sewer D1 | October 9 | 1400 | 3.00 |
| Sewer D1 | October 9 | 1415 | 3.00 |
| Sewer D1 | October 9 | 1640 | 3.00 |
| Sewer D1 | October 9 | 1640 | 3.00 |
| Sewer D1 | October 11 | 1640 | 3.00 |
| Sewer D1 | October 12 | 1020 | 3.10 |
| Sewer D1 | October 12 | 1645 | 3.20 |
| Sewer D1 | October 13 | 930 | 4.60 |
| Sewer D1 | October 13 | 1500 | 6.60 |
| Sewer D1 | October 14 | 930 | 5.30 |
| Sewer D1 | October 14 | 1015 | 5.70 |
| Sewer D1 | October 14 | 1100 | 57.90 |
| Sewer D1 | October 14 | 1115 | 15.50 |
| Sewer D1 | October 14 | 1130 | 11.40 |
| Sewer D1 | October 14 | 1145 | 10.60 |
| Sewer D1 | October 14 | 1200 | 16.80 |
| Sewer D1 | October 14 | 1215 | 10.10 |
| Sewer D1 | October 14 | 1230 | 12.50 |
| Sewer D1 | October 14 | 1245 | 14.00 |
| Sewer D1 | October 14 | 1300 | 13.60 |
| Sewer D1 | October 14 | 1315 | 14.30 |
| Sewer D1 | October 14 | 1330 | 15.60 |
| Sewer D1 | October 14 | 1345 | 13.90 |
| Sewer D1 | October 14 | 1400 | 107.00 |
| Sewer D1 | October 14 | 1415 | 125.00 |
| Sewer D1 | October 14 | 1430 | 129.00 |
| Sewer D1 | October 14 | 1445 | 19.30 |

# APPENDIX II

## SEDIMENTS

SEDIMENT ANALYSES

| Sampling Site | Depth (cm) | Hg (mg/kg) |
|---|---|---|
| A | 0- 2 | 32 |
| | 2- 5 | 50 |
| | 5-10 | 69 |
| | 10-15 | 132 |
| | 15-20 | 167 |
| B | 0- 2 | 127 |
| | 2- 5 | 103 |
| | 5-10 | 75 |
| | 10-15 | 84 |
| | 15-18 | 72 |
| C | 0- 5 (scoop) | 37 |
| D | 0- 5 (scoop) | 6.0 |
| E | 0- 5 (scoop) | 8.0 |
| F | 0- 5 | 28 |
| G | 0- 5 | 16 |
| | 5-10 | 23 |
| | 10-15 | 18 |
| | 15-20 | 1.2 |
| | 20-25 | 4.0 |
| | 25-30 | 5.0 |
| H | 0- 2 | 42 |
| | 2- 7 | 131 |
| | 7-12 | 29 |
| | 12-17 | 29 |
| | 17-22 | 127 |
| I | 0- 3 | 338 |
| | 3- 8 | 164 |
| J | 0- 7 | 48 |
| | 2- 7 | 40 |
| | 7-12 | 30 |
| K | 0- 5 (scoop) | 141 |
| L | 0- 2 | 151 |
| | 2- 4 | 81 |
| | 4- 9 | 34 |
| M | 0- 4 | 9.1 |
| | 4- 9 | 46 |
| | 9-13 | 41 |
| | 13-18 | 37 |
| | 18-22 | 13 |

| Sampling Site | Depth (cm) | Hg (mg/kg) |
|---|---|---|
| N | 0- 5 (scoop) | 11.2 |
| O | 0- 5 (scoop) | 9.6 |
| P | 0- 5 | 7.9 |
| Q | 0- 5 | 45 |
| R | 0- 5 | 44 |
| S | 0- 5 | 8.2 |
| T | 0- 5 | 40 |
| U | 0- 5 | 21 |
| V | 0- 5 | 32 |
| W | 0- 5 | 10 |

| Sampling Site | Depth (cm) | Hg (mg/kg) |
|---|---|---|
| (below flume) | | |
| a | 0- 5 | 6.9 |
| b | 0- 5 | 30 |
| c | 0- 5 | 3.3 |
| d | 0- 5 | 3.7 |
| | 5-10 | 0.9 |
| e | 0- 5 | 1.8 |
| f | 0- 5 | 0.84 |
| g | 0- 5 | 0.88 |

# APPENDIX III

## PRODUCTS AND MISCELLANEOUS

## APPENDIX III

| PRODUCT | MERCURY CONCENTRATION | |
|---|---|---|
| Filtered Caustic (Dryden Chemicals) | 105.5 | ug/l |
| "Hypo" (Dryden Chemicals) | 140 | ug/l |
| Chlorate (Dryden Chemicals) | 640 | ug/l |
| Hydrochloric Acid (Dryden Chemicals) | 2600 | ug/l |
| Mimeo 36M paper (Reed Paper) | 0.01 | mg/kg |
| Bond 32M paper (Reed Paper) | 0.01 | mg/kg |
| Offset 160M 24" (Reed Paper) | 0.01 | mg/kg |
| Envelope Sub 24" (Reed Paper) | 0.01 | mg/kg |
| Full Bleached Pulp (Reed Paper) | 0.01 | mg/kg |
| Semi-Bleached Pulp (Reed Paper) | 0.01 | mg/kg |
| Nu-dry Unbleached Pulp (Reed Paper) | 0.01 | mg/kg |

FILTRATION COMPARISON

| SAMPLE SOURCE | MERCURY (ug/l) FILTERED | MERCURY (ug/l) UNFILTERED |
|---|---|---|
| Treatment Tank | 9.7 | 28.7 |
| Sewer B1 | 0.60 | 2.7 |
| Causeway | 0.67 | 1.0 |
| Sewer E | 0.16 | 0.22 |

PRESERVATION COMPARISON

| SAMPLE SOURCE | MERCURY (ug/l) PRESERVED | MERCURY (ug/l) UNPRESERVED |
|---|---|---|
| West Header | 0.27 | 0.04 |
| East Header | 0.27 | 0.04 |
| Causeway (sampled in quadruplicate) | 0.41 | 0.47 |
| | 0.42 | 0.28 |
| | 0.37 | 0.35 |
| | 0.45 | 0.30 |
| Sewer B1 (sampled in duplicate) | 1.1 | 0.97 |
| | 1.2 | 0.97 |